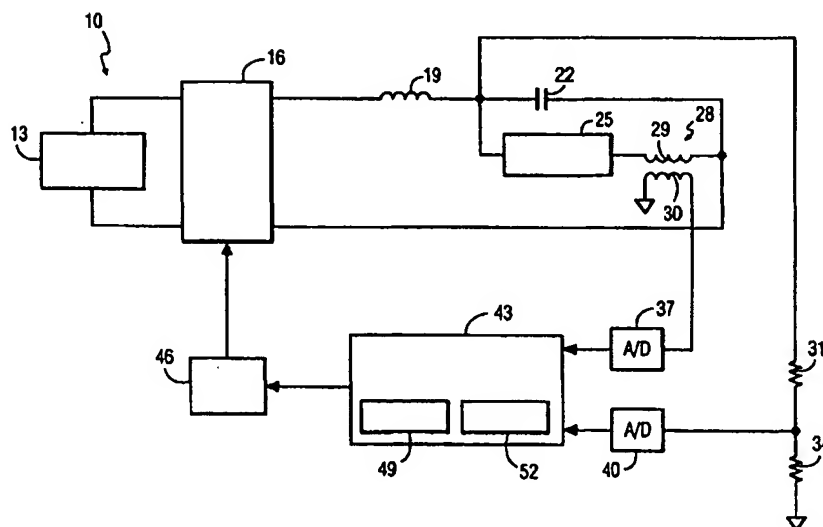


PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H05B 41/36	A1	(11) International Publication Number: WO 00/07415 (43) International Publication Date: 10 February 2000 (10.02.00)
(21) International Application Number: PCT/EP99/05035 (22) International Filing Date: 14 July 1999 (14.07.99) (30) Priority Data: 09/124,428 29 July 1998 (29.07.98) US (71) Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (72) Inventors: GIANNOPOULOS, Demetri; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). WANG, Shenghong; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). (74) Agent: BOSMA, Rudolphus, H., A.; Internationaal Octrooi- bureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).		(81) Designated States: CN, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: ELECTRONIC BALLAST



(57) Abstract

A ballast for operating different types of lamp loads (25) through identification of the lamp type during steady state operation of the lamp load (25). Lamp type recognition is achieved based on a comparison of the lamp load voltage and lamp load current data points stored in a random-access memory (49) of a microprocessor (43) to a plurality of V-I characteristic curves stored in a read-only memory (52) of the microprocessor (43). Through this comparison, the ballast (10) can distinguish among a number of different lamp loads (25) having the same starting voltage.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

Electronic ballast.

This invention relates generally to an electronic ballast and, more particularly, to a scheme for identifying the type of fluorescent lamp which is being powered by the electronic ballast.

There are many different types of fluorescent lamps including preheat and rapid
5 start. Not only do each of these lamp types have different ratings for ignition and/or steady state operation but within each lamp type there are different ratings for ignition and/or steady state operation. These differences can be expressed, in part, by voltage-current (V-I) characteristic curves. A ballast inverter should be driven based on the V-I characteristic curve of the lamp.

10 A typical ballast is designed to supply a specific starting voltage and load current based on the V-I characteristic curve of the lamp to be powered by the ballast. Different ballasts are therefore required based on the lamp load to be powered. No one ballast can be used for all these different types of lamps. With the increasing number of lamps available, more and more different types of ballasts are required. Many of these lamps are
15 produced in relatively small numbers, making the manufacturing cost for the associated ballast relatively high. Ballasts designs are further complicated by the number of different ballasts designs required.

One approach which has been proposed in attempting to solve the foregoing problems, as disclosed in U.S. Patent No. 5,039,921, identifies the lamp to be powered based
20 on the lamp's starting voltage. Three different types of V-I characteristic curves are stored in and can be accessed from a memory based on the lamp's starting voltage. The accessed V-I characteristic curve is used in driving the ballast inverter. Unfortunately, many lamps have the same or about the same starting voltage and therefore cannot be distinguished from each other based on the starting voltage. The starting voltage also changes during the lifetime of the lamp
25 thereby complicating recognition of the lamp based on starting voltage.

It is therefore desirable to provide an improved electronic ballast which can power a number of different types of lamp loads. The improved ballast should be able to distinguish among a number of different lamp loads having the same starting voltage.

In accordance with a first aspect of the invention, a method for operating a ballast includes the steps of providing a sufficient starting voltage for ignition of a lamp load, adjusting the lamp load current to at least two different levels, measuring the lamp load voltage corresponding to each of the at least two different lamp load current levels, comparing
5 the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves, selecting the curve which best matches these at least two different levels, and operating the ballast based on the selected curve.

The ballast can power a number of different types of lamp loads through identification of the lamp type during steady state operation of the lamp load. Lamp type
10 recognition is achieved based on a comparison of the lamp voltage and lamp current to a plurality of V-I characteristic curves. Through this comparison, the ballast can distinguish among a number of different lamp loads having the same starting voltage.

It is a feature of the invention that the method further includes storing the lamp load current and associated lamp load voltage for each of these at least two different levels and
15 plurality of lamp V-I characteristic curves in a microprocessor. In another feature of the invention, the method further includes producing switching signals to an inverter from a driver based on a signal outputted from the microprocessor. Preferably, the at least two different levels of lamp load current are less than 50% of the nominal current rating of each of the lamp loads that can be powered by the inverter.

20 In accordance with a second aspect of the invention, a ballast includes an inverter responsive to switching signals for powering one of at least two different lamp loads wherein each lamp load has a different V-I characteristic curve. The ballast also includes a microprocessor and a driver responsive to the microprocessor output signal for generating the switching signals. The microprocessor adjusts the current flowing through the lamp load to at
25 least two different levels following ignition of the lamp load, measures the lamp load voltage corresponding to each of the at least two different lamp load current levels and compares the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves. The microprocessor produces the microprocessor output signal based on the curve which best matches these at least two
30 different levels.

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a partial block diagram and partial electrical schematic in accordance with the invention;

Fig. 2 is a flow chart of a lamp recognition scheme;

Fig. 3 is a plot illustrating several V-I characteristics curves; and

5 Figs. 4A and 4B are plots of the lamp voltage and lamp current versus time, respectively.

As shown in Fig. 1, a ballast 10 includes a DC source 13 which supplies a substantially DC voltage or current to an inverter 16, the latter of which can be of the full
10 bridge or half bridge type. A high frequency pulse train, which can vary in frequency and/or pulse width, is supplied to a series resonant LC circuit which includes an inductor 19 and a capacitor 22. A serial combination of a lamp load 25 and a primary winding 29 of a current transformer 28 is connected in parallel across capacitor 22. The series resonant LC circuit filters the pulse train so as to apply a substantially high frequency sinusoidal waveform to
15 lamp load 25.

A voltage divider formed from a serial combination of a pair of resistors 31 and 34 is connected between ground and a junction joining inductor 19 to capacitor 22. The current flowing through lamp 25 (i.e. I_{LAMP}) is sensed by a secondary winding 30 of transformer 28 and applied to an analog to digital converter (A/D) 37. The voltage across the
20 serial combination of lamp load 25 and primary winding 29, which is essentially the voltage across lamp load 25 (i.e. V_{LAMP}), is sensed by the voltage divider and applied to an analog to digital converter (A/D) 40. A pair of digital signals representing I_{LAMP} and V_{LAMP} are supplied by converters 37 and 40, respectively, to a microprocessor 43.

Microprocessor 43 outputs a signal to a driver 46, the latter of which in
25 response to the microprocessor output signal controls the frequency and/or pulse width of the switching signals supplied to inverter 16. These switching signals determine the frequency and/or pulse width of the pulse train outputted by inverter 16. During steady state operation of lamp load 25, the microprocessor output signal reflects the V-I characteristic curve of lamp load 25.

30 The V-I characteristic curve chosen by microprocessor 43 is based on a sequence of steps as shown in FIG. 2. Under a step 101, lamp load 25 first passes through ignition. Once lamp load 25 is in its steady state mode of operation, under a step 104 microprocessor 25 sets the value of $i=1$. Under a step 107, the microprocessor output signal now reflects setting the value of $I_{LAMP}=I_{LAMPi}$. The switching signals produced by driver

46, which are supplied to inverter 16, in response to the microprocessor output signal result in $ILAMP = ILAMP_i$. Under a step 110, the value of $VLAMP_i$ is now measured by microprocessor 43 based on the signal produced by A/D 40. The values of $VLAMP_i$ and $ILAMP_i$ are temporarily stored in a random access memory. The value of i is checked under
5 step 113 to determine if $i = n$, where n is equal to at least 2. In the event that i is not yet equal to n , the value of i incremented by a value of 1 under step 116. Steps 107 through 116 are repeated until under step 113 $i = n$. The lamp type is then determined by microprocessor 43 under step 119. Assuming $n = 3$, three different sets of $VLAMP$ and $ILAMP$ values stored in memory 49 are compared to the plurality of V-I characteristic curves stored in a read-only
10 memory 52. The V-I characteristic curve which best matches the values of $VLAMP_i$ and $ILAMP_i$ is chosen by microprocessor 43 and used in producing the microprocessor output signal.

A sample of the V-I characteristic curves stored in memory 52 is illustrated in Fig. 3. Four V-I characteristic curves 201, 204, 207 and 210 represent nominally rated 40 watt,
15 36 watt, 24 watt and 18 watt fluorescent lamps, respectively. The curves stored in memory 52 should include curves for all of the different types of lamps which ballast 10 could be expected to power. The value of n should be chosen so that there are a sufficient number of $VLAMP_i$ and associated $ILAMP_i$ values from which to choose among the plurality of curves stored in memory 52. In other words, the value of n can be, if required, greater than $n = 2$. All values of
20 $ILAMP_i$ set by microprocessor 43 are less than the nominal current rating of lamp load 25 (i.e. current rating of lamp load 25 at full illumination) in order to protect the latter from damage. Preferably, $ILAMP_{i+1}$ is greater than $ILAMP_i$ such that $ILAMP_n$ is the highest value of $ILAMP$ set by microprocessor 43. In one preferred embodiment of the invention when $n = 3$, $ILAMP_1$, $ILAMP_2$ and $ILAMP_3$ are chosen so as to be equal to 25%, 35% and 45% of the
25 nominal current rating of the lamp load that has the highest nominal current rating of all the lamp loads that can be operated by the ballast, respectively.

Referring now to Figs. 4A and 4B, the values of $VLAMP$ (Fig. 4A) and $ILAMP$ (Fig. 4B) are plotted for $n = 3$. As shown in Fig. 4A, the voltage across lamp load 25 is raised until lamp load 25 ignites at time t_1 . Following ignition, the voltage across lamp load 25
30 decreases and the level of current flowing in lamp load 25 increases. Lamp load 25 is now in its steady state of operation. At time t_2 , microprocessor 43 has set $ILAMP_i$ to a value of I_1 . The value of $VLAMP$ (i.e. V_1) is determined by microprocessor 43 based on the signal produced by A/D 40 and stored within memory 49. Microprocessor 43 at time t_3 has set $ILAMP_i$ to a value of I_2 , determines the value of $VLAMP$ (i.e. V_2) and stores the latter in

memory 49. Microprocessor 43 at time t_4 has set $ILAMP_i$ to a value of I_3 , determines the value of $VLAMP$ (i.e. V_3) and stores the latter in memory 49. The three different sets of $VLAMP$ and $ILAMP$ values stored in memory 49 are now compared to the plurality of V-I characteristic curves stored in memory 52. The V-I characteristic curve which best matches the values of $VLAMP_i$ and $ILAMP_i$ is chosen by microprocessor 43 and used in producing the microprocessor output signal.

The level of lamp current I_3 is substantially less than the current level at full illumination (i.e. denoted as "max light") for lamp load 25. Operation of lamp load 25 in regions near or above its nominal rating is thereby avoided. Once lamp load 25 has been identified, microprocessor 43 adjusts the lamp current to a desired level as determined by the user. For example, when ballast 10 is used in combination with a dimmer (not shown), microprocessor 43 will control the level of lamp load illumination to the level set by the dimmer including, if desired, to the lowest level of illumination possible. (denoted as "min light").

As can now be readily appreciated, ballast 10 can power a number of different types of lamp loads through identification of the lamp type during steady state operation of lamp load 25. Lamp type recognition is achieved based on a comparison of the lamp voltage and lamp current data points stored in memory 49 to the plurality of V-I characteristic curves stored in memory 52. Through this comparison, ballast 10 can distinguish among a number of different lamp loads having the same starting voltage.

It will thus be seen that the objects set forth above and those made apparent from the preceding description are efficiently attained and since certain changes may be made in the above construction without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

CLAIMS:

1. A method for operating a ballast (10) in dependency of a lamp load connected to the ballast comprising the step of:
providing a sufficient starting voltage for ignition of a lamp load (101);
characterized in that the method further comprises the steps of:
5 adjusting the lamp load current to at least two different levels (107,116);
measuring the lamp load voltage corresponding to each of the at least two different lamp load current levels (110);
comparing the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves (119);
10 selecting the curve (201, 204, 207, 210) which best matches these at least two different levels;
and
operating the ballast based on the selected curve.
2. The method of claim 1, further including storing the lamp load current and
15 associated lamp load voltage for each of these at least two different levels and a plurality of lamp V-I characteristic curves in a microprocessor (43).
3. The method of claim 2, further including producing switching signals to an
inverter (16) from a driver (46) based on a signal outputted from the microprocessor (43).
20
4. The method of claim 1, wherein the at least two different levels of lamp load current are less than 50% of the nominal current rating of the lamp load with the highest nominal current rating that can be operated by the ballast.
- 25 5. The method of claim 3, wherein the at least two different levels of lamp load current are less than 50% of the nominal current rating of the lamp load with the highest nominal current rating that can be operated by the ballast.
6. A ballast (10), comprising:

an inverter (16) responsive to switching signals for powering one of at least two different lamp loads, each lamp load (25) having a different V-I characteristic curve;
a driver (46) responsive to a microprocessor output signal for generating the switching signals;
and;

- 5 a microprocessor (43) for generating the microprocessor output signal in dependency of a lamp load connected to the ballast,
characterized in that the microprocessor is programmed for adjusting the current flowing through the lamp load to at least two different levels following ignition of the lamp load, measuring the lamp load voltage corresponding to each of the at least two different lamp load
10 current levels, comparing the lamp load current and associated lamp load voltage for each of these at least two different levels to a plurality of lamp V-I characteristic curves (201, 204, 207, 210) and selecting the curve which best matches these at least two different levels and producing the microprocessor output signal based on the selected curve.

- 15 7. A ballast according to claim 6, wherein the at least two different levels of lamp load current are less than 50% of the nominal current rating of the lamp load with the highest nominal current rating that can be operated by the ballast.

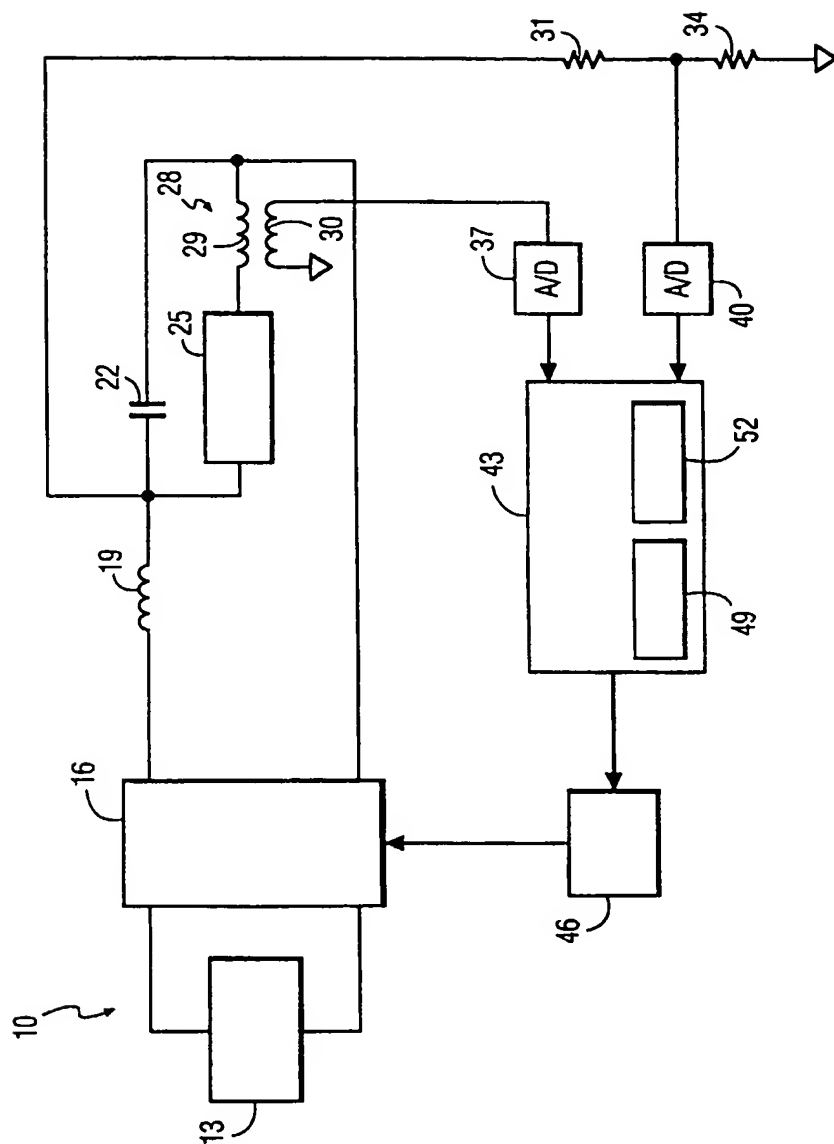


FIG. 1

2/3

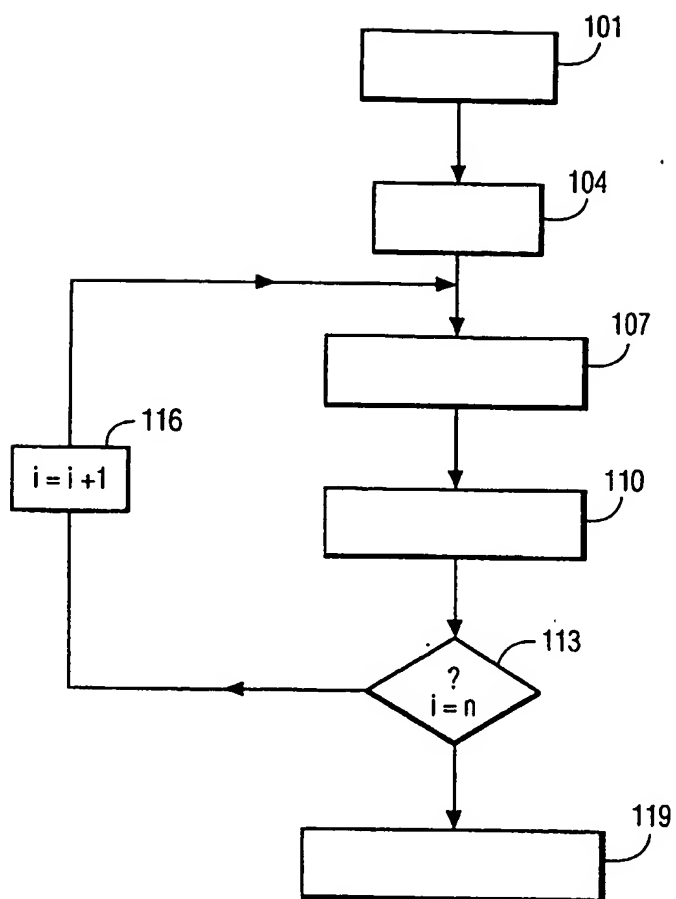


FIG. 2

3/3

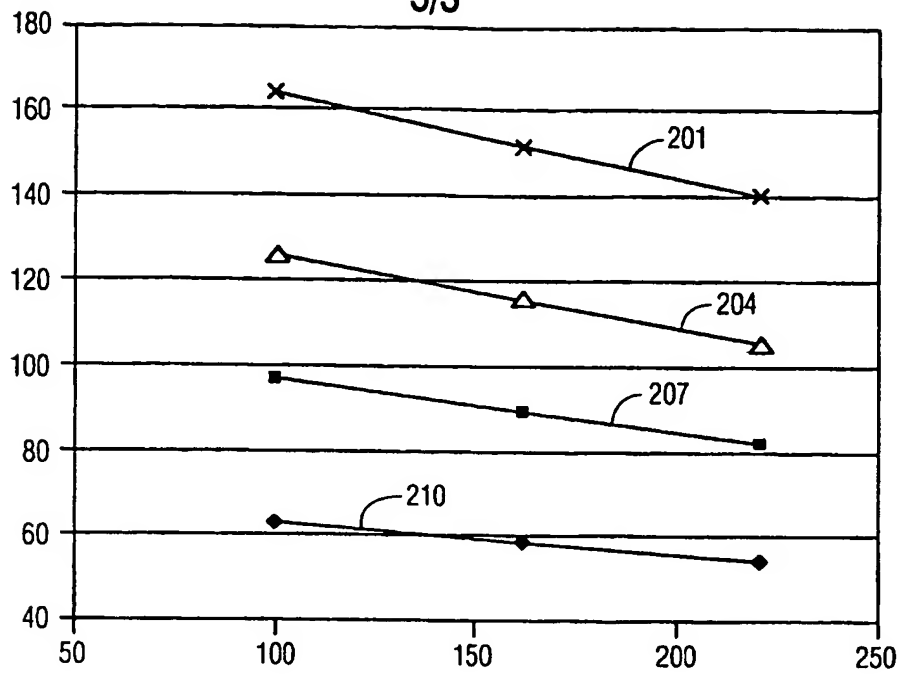


FIG. 3

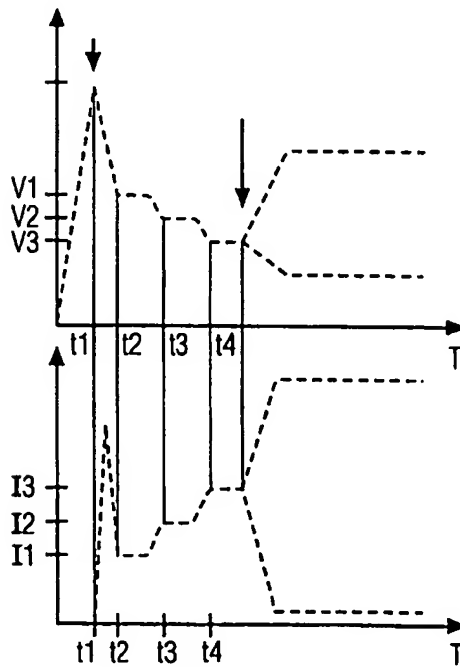


FIG. 4A

FIG. 4B

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/EP 99/05035

A. CLASSIFICATION OF SUBJECT MATTER

H05B41/36

According to International Patent Classification (IPC) or to both national classification and IPC 7

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI, Week 199525, Derwent Publications Ltd., London, GB; Klasse H05B, AN 1995-188703; & JP 07 106088 A (ORIGIN ELECTRIC), 21 April 1995, abstract. --	1, 6
A	EP 0127101 A (SIEMENS AG) 05 December 1984, abstract, claims, fig.. --	1, 6
A	EP 0637195 A (S.A. METAS) 01 February 1995, abstract, claim 3, fig.. ----	1, 6

☐ Further documents are listed in the continuation of box C.☐ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search
10 November 1999Date of mailing of the international search report
21 12 1999Name and mailing address of the ISA
European Patent Office, P.O. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

FELLNER e.h.

ANHANG

zum Internationalen Recherchen-
bericht über die internationale
Patentanmeldung Nr.

ANNEX

to the International Search
Report to the International Patent
Application No.

ANNEXE

au rapport de recherche inter-
national relatif à la demande de brevet
international n°

PCT/EP 99/05035 SAE 243641

In diesem Anhang sind die Mitglieder
der Patentfamilien der in obenge-
nannten internationalen Recherchenbericht
angeführten Patentdokumente angegeben.
Diese Angaben dienen nur zur Unter-
richtung und erfolgen ohne Gewähr.

This Annex lists the patent family
members relating to the patent documents
cited in the above-mentioned inter-
national search report. The Office is
in no way liable for these particulars
which are given merely for the purpose
of information.

La présente annexe indique les
membres de la famille de brevets
relatifs aux documents de brevets cités
dans le rapport de recherche inter-
national visé ci-dessus. Les renseigne-
ments fournis sont donnés à titre indica-
tif et n'engagent pas la responsabilité
de l'Office.

In Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche		Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
JP A2	7106088	21-04-1995	keine - none - rien	
EP A1	127101	05-12-1984	AT E 25800	15-03-1987
			DE A1 3319352	29-11-1984
			DE C0 3462574	09-04-1987
			EP B1 127101	04-03-1987
			FI A0 841794	04-05-1984
			FI A 841794	28-11-1984
			FI E 76906	31-08-1988
			FI C 76906	12-12-1988
EP A1	637195	01-02-1995	AT E 160253	15-11-1997
			AU A1 73871794	28-02-1995
			DE C0 69406796	18-12-1997
			EP T2 69406796	25-06-1998
			EP A1 711498	15-05-1996
			EP B1 711498	12-11-1997
			ES T3 2113120	16-04-1998
			IT A0 BQ 930339	30-07-1993
			IT B1 1264183	23-09-1996
			WO A1 9504446	09-02-1995